Equatorial Oscillations in Jupiter's and Saturn's Atmospheres

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Equatorial oscillations in the zonal-mean temperatures and zonal winds have been well documented in Earth's middle atmosphere. A growing body of evidence from ground-based and Cassini spacecraft observations indicates that such phenomena also occur in the stratospheres of Jupiter and Saturn. Earth-based mid-infrared measurements spanning several decades have established that the equatorial stratospheric temperatures on Jupiter vary with a cycle of 4–5 years and on Saturn with a cycle of ~15 years. Spectra obtained by the Composite Infrared Spectrometer (CIRS) during the Cassini swingby at the end of 2000, with much better vertical resolution than the ground-based data, indicated a series of vertically stacked warm and cold anomalies at Jupiter's equator; a similar structure was seen at Saturn's equator in CIRS limb measurements made in 2005, in the early phase of Cassini's orbital tour. The thermal wind equation implied similar patterns of mean zonal winds increasing and decreasing with altitude. On Saturn the peak-to-peak amplitude of this variation was nearly 200 m s^{-1}. The alternating vertical pattern of warmer and colder equatorial temperatures and easterly and westerly tendencies of the zonal winds is seen in Earth's equatorial oscillations, where the pattern descends with time. The Cassini Jupiter and early Saturn observations were snapshots within a limited time interval, and they did not show the temporal evolution of the spatial patterns. However, more recent Saturn observations by CIRS (2010) and Cassini radio-occultation soundings (2009-2010) have provided an opportunity to follow the change of the temperature-zonal wind pattern, and they suggest there is descent, at a rate of roughly one scale height over four years. On Earth, the observed descent in the zonal-mean structure is associated with the absorption of a combination of vertically propagating waves with easterly and westerly phase velocities. The peak-to-peak zonal wind amplitude in the oscillation pattern and the rate of descent constrain the absorbed wave flux of zonal momentum. On Saturn this is ~0.05 m^2s^{-2}, which is comparable to if not greater than that associated with the terrestrial oscillations. We discuss possible candidates for the absorbed waves on Saturn. On Earth the wave forcing of the equatorial oscillation generates secondary circulations that can affect the temperature and wind structure at latitudes well away from the equator, and we discuss possible evidence of that on Saturn.